Appendix 6a: Additional Benefits Information

Summary

This appendix provides additional information regarding the benefits analysis, including (1) methods for developing estimate of full attainment air quality; (2) the process for interpolating the 0.075 ppm and 0.079 ppm benefits estimates; (3) the partial attainment PM2.5 incidence and valuation estimates.

6a.1 Developing an Air Quality Estimate of Full Attainment with the Alternative Ozone Standards

As discussed in chapter 3, the modeled attainment scenarios were not sufficient to simulate full attainment with each of the three alternative ozone standards analyzed. To meet our analytical goal of estimating the human health benefits of full simulated attainment with each of these standard alternatives, it became necessary to derive an estimate of the full attainment air quality increment through a simple monitor rollback approach.

We rolled back the values at each monitor such that no monitor in the U.S. exceeded the alternative standard in question. This approach makes the bounding assumption that ozone concentrations can be reduced only at monitors projected to exceed the alternative standards. From a benefits perspective, this approach leads to a downward bias in the estimates because populations are assumed to be exposed at a distance weighted average of surrounding monitors. Thus, any individual's reduction in exposure from a change at a given monitor will be weighted less if there are other attaining monitors in close proximity.

We determined projected attainment status of each monitor by calculating design values. However, to estimate changes in ozone-related health effects resulting from improvement in air quality, the BenMAP model requires a series of metrics. When performing a benefits assessment with air quality modeling data, BenMAP calculates these metrics based on the distribution of CMAQ-modeled hourly ozone concentrations for the ozone season. However, because we were performing a benefits assessment based on monitor values that have been rolled-back, it was necessary to derive each of these metrics outside of the BenMAP model. Thus, we first developed a scaling ratio that related the calculated design value to each of the ozone metrics.

A summary of this procedure is as follows:

1. Import partial attainment 0.08 ppm calculated design values into the BenMAP model

2. Perform a spatial interpolation of these design values using the Voronoi Neighborhood Averaging algorithm. Design values are then interpolated to the CMAQ grid cell.

3. Import distribution of air quality modeled daily and hourly ozone concentrations into BenMAP. Create air quality grid in BenMAP using spatial and temporal scaling

technique.[1] This procedure creates grid cell level summer season ozone metrics (1 hour maximum, 5 hour average, 8 hour maximum, 8 hour average and 24 hour average).

4. Calculate grid cell-level ratio of each ozone metric to calculated design value. The result of this calculation is a grid cell-level ratio of metric to design value that can then be subsequently used to scale the calculated design value and thus derive each of the metrics.

After having calculated these scaling ratios we then performed the monitor rollback as follows:

1. Roll back the calculated 0.08 ppm partial attainment design value to just equal the 0.08 ppm standard. This process creates a new baseline design value grid.

2. Scale the design value grid cell values to ozone metric grid cell values by using ratios described above.

3. Create new 0.084 ppm baseline air quality grid from grid cell-level ozone metrics.

4. Roll back the calculated 0.070 ppm and 0.065 ppm partial attainment design values at each monitor to just reach the 0.070 ppm and 0.065 ppm standards, respectively.

5. Scale the calculated full attainment design value to grid cell-level ozone metric using ratios described above.

6. Create new 0.070 ppm and 0.065 ppm air quality grids from grid cell-level ozone metrics.

7. Perform benefits analysis with baseline and control grids.

To develop the full attainment air quality grids for 0.075 ppm and 0.079 ppm, we performed an interpolation of the 0.070 ppm full attainment air quality grid, rather than a monitor rollback. We used this technique because air quality modeling incorporating control strategies was only available for 0.070 ppm. This interpolation for 0.075 ppm entailed the following steps:

1. We identified any monitors that were projected to not attain 0.075 ppm alternative in the 0.084 ppm base case air quality grid.

2. For these monitors we calculated an adjustment factor that would scale down the air quality improvement at that monitor. The purpose of this adjustment was to ensure that the improvement in air quality at that monitor reflected the attainment of the 0.075 ppm standard. This ratio was calculated by dividing the improvement in the design value necessary to attain 0.075 ppm by the improvement in the design value necessary to attain 0.070 ppm. For example, a monitor whose baseline is 0.084 would receive 2/3 of the air quality improvement from attaining 0.075 ppm than they would from attaining 0.070 ppm.

[1] BenMAP Technical Appendices, Abt Associates: May 2005. Page C-12.

3. We then interpolated these monitor-specific ratios to the grid cell-level in BenMAP, constraining the interpolation to within 200 km of the control buffer.

4. Finally, we used these grid cell-level ratios as the basis for scaling down the grid cell-level estimates of incidence and valuation from the 0.070 ppm analysis.

5. Next, we followed the same process for the 0.079 ppm interpolation.

6a.2 Partial Attainment $PM_{2.5}$ Incidence and Valuation Estimates

Tables 6a.1 through 6a.5 below summarize the estimates of $PM_{2.5}$ incidence and valuation resulting from the 0.070 ppm partial attainment scenario. These estimates provided the basis for the full attainment $PM_{2.5}$ co-benefit estimates found in Chapter 6 of this RIA. Details about the methodology for this approach can also be found in Chapter 6.

Table 6a.1: Illustrative 0.070 ppm Partial Attainment Scenario: Estimated Reductions in PM Premature Mortality associate with PM Co-Benefit (95th percentile confidence intervals provided in parentheses)[c]

	Eastern U.S.	Western U.S. Excluding California	California	National PM Co-Benefits
Mortality Impact Functions Derived from Epidemiology Literature				
ACS Study[a]	420 (110--730)	6.3 (2--10)	5.4 (2--9)	430 (110--750)
Harvard Six-City Study[b]	950 (420--1,500)	14 (7--21)	12 (6--18)	980 (440--1,500)
Woodruff et al. 1997 (infant mortality)	1.1 (0.34--1.8)	0.15 (0.07--0.23)	0.02 (0.01--0.04)	1.3 (0.42--2.1)
Mortality Impact Functions Derived from Expert Elicitation				
Expert A	1,600 (-92--3,200)	150 (0.90--310)	32 (3.4--60)	1,800 (-87--3,600)
Expert B	1,200 (-100--2,900)	110 (-4.3--270)	24 (2.3--53)	1,300 (-100--3,200)
Expert C	1,200 (-100--2,900)	120 (-0.89--280)	24 (2.7--54)	1,300 (-99--3,200)
Expert D	830 (42--1,500)	81 (5.7--140)	17 (1.7--28)	920 (49--1,700)
Expert E	2,000 (690--3,300)	190 (76--310)	39 (18--62)	2,200 (790--3,600)
Expert F	1,100 (660--1,700)	110 (66--160)	22 (15--32)	1,200 (740--1,900)
Expert G	690 (0.00--1,400)	68 (0.00--130)	14 (0.00--27)	770 (0.00--1,500)
Expert H	880 (-250--2,300)	86 (-17--220)	18 (-0.93--43)	990 (-270--2,600)
Expert I	1,200 (-14--2,400)	120 (1.5--220)	24 (1.2--44)	1,300 (-11--2,600)
Expert J	950 (44--2,400)	93 (11--230)	19 (5--45)	1,100 (60--2,700)
Expert K	190 (0.00--1,000)	18 (0.00--98)	3.8 (0.00--20)	210 (0.00--1,100)
Expert L	840 (25--1,800)	70 (1.5--170)	16 (1.2--33)	920 (28--2,000)

[a] The estimate is based on the concentration-response (C-R) function developed from the study of the American Cancer Society cohort reported in Pope et al. (2002), which has previously been reported as the primary estimate in recent RIAs.

[b] Based on Laden et al. (2006) reporting of the extended Six-cities study; to be reviewed by the EPA-SAB for advice on the appropriate method for incorporating what has previously been a sensitivity estimate.

[c] All estimates rounded to two significant figures. As such, confidence intervals may not be symmetrical and totals will not sum across columns. All estimates incremental to 2006 PM NAAQS RIA. Estimates do not reflect benefits for the San Joaquin Valley or South Coast Air Basins. Negative values indicate that an increase in incidence could occur.

Table 6a.2: Illustrative 0.070 ppm Partial Attainment Scenario: Estimated Reductions in Morbidity Associated with PM Co-Benefit (95th percentile confidence intervals provided in parentheses)[a]

	Eastern U.S.	Western U.S. Excluding California	California	National PM Co-Benefits
Morbidity Impact Functions Derived from Epidemiology Literature				
Chronic Bronchitis (age >25 and over)	380 (-11--760)	38 (4--72)	8.7 (1--17)	420 (-6--850)
Nonfatal myocardial infarction (age >17)	970 (440--1,500)	12 (6--18)	11 (5--16)	1,000 (450--1,500)
Hospital admissions—respiratory (all ages)	120 (46--184)	1.3 (1--2)	1.1 (1--2)	120 (46--186)
Hospital admissions—cardiovascular (age >17)	230 (127--340)	2.8 (2--4)	2.3 (1--3)	240 (130--340)
Emergency room visits for asthma (age <19)	400 (200--610)	3.6 (2--5)	2.4 (1--4)	410 (200--620)
Acute bronchitis (age 8–12)	980 (-310--2,300)	120 (-16--250)	23 (-3--50)	1,100 (-320--2,600)
Lower respiratory symptoms (age 7–14)	7,100 (2,600--12,000)	150 (63--230)	130 (57--210)	7,400 (2,800--12,000)
Upper respiratory symptoms (asthmatic children age 9–18)	5,200 (880--9,500)	110 (27--190)	95 (24--170)	5,400 (930--9,900)
Asthma exacerbation (asthmatic children age 6–18)	6,500 (-78--21,000)	130 (10--420)	120 (9--380)	6,800 (-60--22,000)
Work loss days (age 18–65)	47,000 (39,000--54,000)	830 (710--950)	800 (680--910)	48,000 (41,000--56,000)
Minor restricted activity days (age 18–65)	280,000 (220,000--330,000)	4,800 (4,000--5,700)	4,700 (3,900--5,500)	290,000 (230,000--340,000)

[a] All estimates rounded to two significant figures. As such, confidence intervals may not be symmetrical and totals will not sum across columns. All estimates incremental to 2006 PM NAAQS RIA. Estimates do not reflect benefits for the San Joaquin Valley or South Coast Air Basins. Negative values indicate that an increase in incidence could occur.

Table 6a.3: Illustrative Strategy to Partially Attain 0.070 ppm: Estimated Partial Attainment Value of Reductions in PM2.5-Related Premature Mortality Associated with PM Co-Benefit (3 percent discount rate, in millions of 2006$) 95th Percentile Confidence Intervals Provided in Parentheses[c]

	Eastern U.S.	Western U.S. Excluding California	California	National PM Co-Benefits
Mortality Impact Functions Derived from Epidemiology Literature				
ACS Study[a]	$3,000 ($380--$7,000)	$44 ($6.8--$110)	$38 ($5.8--$95)	$3,000 ($440--$7,200)
Harvard Six-City Study[b]	$6,700 ($1,000--$14,000)	$99 ($16--$210)	$85 ($14--$180)	$6,900 ($1,000--$15,000)
Woodruff et al., 1997 (infant mortality)	$7.5 ($1.0--$17)	$1.0 ($0.16--$2.3)	$0.17 ($0.03--$0.36)	$8.8 ($1.2--$20)
Mortality Impact Functions Derived from Expert Elicitation				
Expert A	$11,000 ($200--$30,000)	$1,100 ($55--$2,800)	$220 ($20--$560)	$12,000 ($280--$33,000)
Expert B	$8,400 (-$600--$28,000)	$790 (-$23--$2,700)	$170 ($9.0--$520)	$9,300 (-$620--$31,000)
Expert C	$8,300 (-$33--$27,000)	$810 ($32--$2,600)	$170 ($15--$500)	$9,300 ($13--$30,000)
Expert D	$5,800 ($480--$15,000)	$570 ($53--$1,400)	$120 ($13--$280)	$6,500 ($540--$16,000)
Expert E	$14,000 ($2,000--$32,000)	$1,300 ($200--$3,000)	$280 ($43--$600)	$15,000 ($2,300--$35,000)
Expert F	$7,600 ($1,400--$17,000)	$740 ($130--$1,600)	$150 ($27--$330)	$8,500 ($1,400--$19,000)
Expert G	$4,900 ($0.00--$13,000)	$480 ($0.00--$1,300)	$98 ($0.00--$260)	$5,400 ($0.00--$14,000)
Expert H	$6,200 (-$1,700--$21,000)	$610 (-$100--$2,000)	$120 ($0.26--$390)	$6,900 (-$1,700--$23,000)
Expert I	$8,200 ($430--$22,000)	$810 ($53--$2,100)	$170 ($14--$420)	$9,200 ($500--$24,000)
Expert J	$6,700 ($430--$22,000)	$650 ($61--$2,100)	$130 ($17--$410)	$7,400 ($520--$24,000)
Expert K	$1,300 ($0.00--$8,200)	$130 ($0.00--$800)	$27 ($0.00--$160)	$1,500 ($0.00--$9,200)
Expert L	$5,900 ($240-$17,000)	$490 ($7.2--$1,600)	$110 ($5.7--$330)	$6,500 ($260--$19,000)

[a] The estimate is based on the concentration-response (C-R) function developed from the study of the American Cancer Society cohort reported in Pope et al. (2002), which has previously been reported as the primary estimate in recent RIAs.

[b] Based on Laden et al. (2006) reporting of the extended Six-cities study; to be reviewed by the EPA-SAB for advice on the appropriate method for incorporating what has previously been a sensitivity estimate.

[c] All estimates rounded to two significant figures. As such, confidence intervals may not be symmetrical and totals will not sum across columns. All estimates incremental to 2006 PM NAAQS RIA. Estimates do not reflect benefits for the San Joaquin Valley or South Coast Air Basins. Negative values indicate that an increase in incidence could occur.

Table 6a.4: Illustrative Strategy to Partially Attain 0.070 ppm: Estimated Partial Attainment Value of Reductions in $PM_{2.5}$-Related Premature Mortality Associated with PM Co-Benefit (7 percent discount rate, in millions of 2006\$) 95th Percentile Confidence Intervals Provided in Parentheses[c]

	Eastern U.S.	Western U.S. Excluding California	California	National PM Co-Benefits
Mortality Impact Functions Derived from Epidemiology Literature				
ACS Study[a]	$2,700 ($340--$6,300)	$40 ($6.8--$110)	$34 ($5.8--$95)	$2,700 ($360--$6,400)
Harvard Six-City Study[b]	$6,000 ($920--$13,000)	$89 ($14--$190)	$77 ($12--$160)	$6,200 ($940--$13,000)
Woodruff et al., 1997 (infant mortality)	$6.8 ($0.90--$16)	$0.94 ($0.14--$2.0)	$0.15 ($0.02--$0.33)	$7.9 ($1.1--$18)
Mortality Impact Functions Derived from Expert Elicitation				
Expert A	$9,900 ($180--$27,000)	$970 ($50--$2,500)	$200 ($18--$510)	$11,000 ($250--$30,000)
Expert B	$7,500 (-$550--$25,000)	$720 (-$20--$2,400)	$150 ($8.1--$470)	$8,400 (-$560--$28,000)
Expert C	$7,500 (-$30--$24,000)	$730 ($28--$2,300)	$150 ($14--$450)	$8,400 ($12--$27,000)
Expert D	$5,200 ($430--$13,000)	$510 ($47--$1,300)	$110 ($11--$250)	$5,800 ($490--$15,000)
Expert E	$12,000 ($1,800--$29,000)	$1,200 ($180--$2,700)	$250 ($39--$540)	$14,000 ($2,000--$32,000)
Expert F	$6,800 ($1,200--$16,000)	$660 ($110--$1,500)	$140 ($24--$300)	$7,600 ($1,300--$17,000)
Expert G	$4,400 ($0.00--$12,000)	$430 ($0.00--$1,200)	$88 ($0.00--$240)	$4,900 ($0.00--$13,000)
Expert H	$5,600 (-$1,500--$19,000)	$550 (-$90--$1,800)	$110 ($0.24--$350)	$6,200 (-$1,600--$21,000)
Expert I	$7,400 ($380--$20,000)	$730 ($48--$1,900)	$150 ($12--$380)	$8,300 ($450--$22,000)
Expert J	$6,000 ($390--$19,000)	$590 ($55--$1,900)	$120 ($16--$370)	$6,700 ($470--$22,000)
Expert K	$1,200 ($0.00--$7,400)	$110 ($0.00--$720)	$24 ($0.00--$150)	$1,300 ($0.00--$8,200)
Expert L	$5,300 ($220--$16,000)	$440 ($6.5--$1,500)	$99 ($5.1--$300)	$5,800 ($230--$17,000)

[a] The estimate is based on the concentration-response (C-R) function developed from the study of the American Cancer Society cohort reported in Pope et al. (2002), which has previously been reported as the primary estimate in recent RIAs.

[b] Based on Laden et al. (2006) reporting of the extended Six-cities study; to be reviewed by the EPA-SAB for advice on the appropriate method for incorporating what has previously been a sensitivity estimate.

[c] All estimates rounded to two significant figures. As such, confidence intervals may not be symmetrical and totals will not sum across columns. All estimates incremental to 2006 PM NAAQS RIA. Estimates do not reflect benefits for the San Joaquin Valley or South Coast Air Basins. Negative values indicate that an increase in incidence could occur.

Table 6a.5: Illustrative Strategy to Partially Attain 0.070 ppm: Estimated Partial Attainment Monetary Value of Reductions in Risk of $PM_{2.5}$-Related Morbidity Reductions Associated with PM Co-Benefit (in millions of 2006$) 95th Percentile Confidence Intervals Provided in Parentheses[a]

	Eastern U.S.	Western U.S. Excluding California	California	National PM Co-Benefits
Morbidity Impact Functions Derived from Epidemiology Literature				
Chronic Bronchitis (age >25 and over)	$180 ($4.0--$870)	$19 ($1.0--$86)	$4.3 ($0.24--$20)	$210 ($5.2--$980)
Nonfatal myocardial infarction (age >17)	$210 ($50--$480)	$2.6 ($0.65--$5.8)	$2.3 ($0.61--$5.2)	$210 ($50--$490)
Hospital admissions—respiratory (all ages)	$2.5 ($1.10--$3.80)	$0.03 ($0.01--$0.04)	$0.02 ($0.01--$0.04)	$ 2.5 ($1.1--$3.8)
Hospital admissions—cardiovascular (age >17)	$6.5 ($3.80--$9.10)	$0.08 ($0.05--$0.11)	$0.06 ($0.04--$0.09)	$6.6 ($3.9--$9.3)
Emergency room visits for asthma (age <19)	$0.15 ($0.07--$0.25)	$0.00 ($0.00--$0.00)	$0.00 ($0.00--$0.00)	$0.15 ($0.07--$0.25)
Acute bronchitis (age 8–12)	$0.50 (-$0.14--$1.50)	$0.06 ($0.00--$0.17)	$0.01 ($0.00--$0.03)	$0.57 (-$0.14--$1.7)
Lower respiratory symptoms (age 7–14)	$ 0.14 ($0.04--$0.29)	$0.00 ($0.00--$0.01)	$0.00 ($0.00--$0.01)	$0.14 ($0.04--$0.30)
Upper respiratory symptoms (asthmatic children age 9–18)	$0.16 ($0.03--$0.41)	$0.00 ($0.00--$0.01)	$0.00 ($0.00--$0.01)	$0.17 ($0.03--$0.42)
Asthma exacerbation (asthmatic children age 6–18)	$0.35 ($0.01--$1.30)	$0.01 ($0.00--$0.03)	$0.01 ($0.00--$0.02)	$0.36 ($0.01--$1.4)
Work loss days (age 18–65)	$5.7 ($4.9--$6.6)	$0.10 ($0.09--$0.11)	$0.12 ($0.10--$0.13)	$6.0 ($5.1--$6.8)
Minor restricted activity days (age 18–65)	$7.8 ($0.39--$16)	$0.14 ($0.01--$0)	$0.13 ($0.01--$0)	$8.1 ($0.40--$17)

[a] All estimates rounded to two significant figures. As such, confidence intervals may not be symmetrical and totals will not sum across columns. All estimates incremental to 2006 PM NAAQS. Estimates do not reflect benefits for the San Joaquin Valley or South Coast Air Basins.